# HairCraft: Spells and Incantations for Digital Hair

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**Figure 1:** *Digital assets from* Warcraft*. Hair types include head, braid, body, and costume. Some creatures render with over 7 million hairs.*

## Abstract

The visual effects pipeline for a photorealistic feature film presents unique challenges for CGI characters and creatures. Some films must match the CGI element to the physical with precision, and some productions require creatures who's presence on the screen can only be distinguished from reality by their fantastical nature. This charade of realism is only further complicated when hair, fur, or feathers are involved. Additional challenges are found in the scale of the film and its production schedule.

In this talk we cover new workflows and tools to meet the demands of state-of-the-art visual effects standards in complexity and production schedules. From Look Development through simulation and rendering, digital hair at Industrial Light & Magic (ILM) is accomplished with HairCraft.

**Keywords:** Hair, Procedural Geometry, Dynamics

**Concepts:** **•Computing methodologies → Simulation tools; Computer graphics;** *Physical simulation;*

## 1 Introduction

We present a new blend of technologies and workflows for creating some of the most realistic and complex digital hair yet seen in feature film. From the award winning bear attack in *The Revenant* to the vast horde of unique and photoreal orcs in *Warcraft*, digital hair at Industrial Light & Magic is realized by the artist with HairCraft.

HairCraft is a proprietary suite of tools from look development to simulation to final render. Front-end tools for creating and managing new levels of complexity directly interface with dynamics to achieve an unprecedented preservation of the lookdev artist's detail and still provide realistic motion. HairCraft is flexible enough to form the basis for feathered creatures and is integrated with procedural geometries such as debris or water.

## 2 Blending Procedural with Digital Sculpt

The HairCraft toolset was developed within ILM's proprietary Zeno application and utilizes procedural geometry built around Zeno's Dataflow framework. Traditional workflows with shaped guide splines define the overall envelope of the hair, but high and medium frequency detail and organic break-up are added by "amplifying" these guide curves through proceduralism.

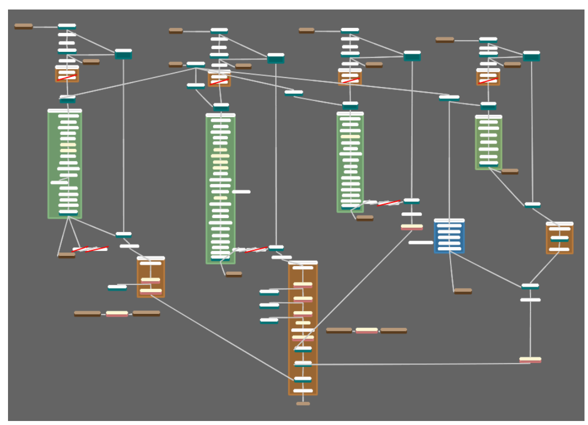

**Figure 2:** *An example ILM HairCraft layer node graph.*

Proceduralism is accomplished by instantiating templates of authored node-based geometry generation and manipulation graphs (2). These graphs are built by both artists and developers using a blend of Python and high-performance, multi-threaded C++ code [Hankins et al. ]. Lookdev artists groom rich and complex hair by placing operations that add many varieties of curl, twist, noise, and hierarchical tufting. Organic variation, forms, and colors are controlled with textures and expressions.

HairCraft also provides two distinct methodologies for allowing artists to utilize representative surface geometry as a volume that can be rigged for animation and serve as a solid guide for the presence of hair in the render. The first method is useful for creating braided hairstyles. Modelers create braided tubes (3a) using their favorite methods (in-house or third party), and lookdev

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**(a)** *Tube Geometry* **(b)** *Volume Geometry* **(c)** *Filled with Hair*

**Figure 3:** *Various hair-volume filling geometries.*

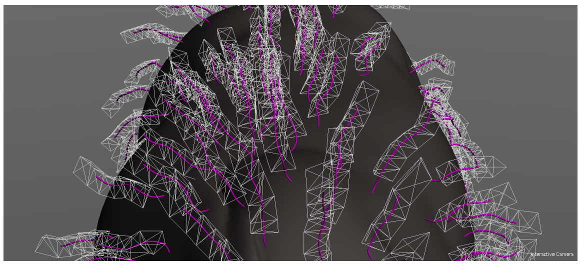

**Figure 4:** *Reduced complexity example of one hair per embedding.*

artists use HairCraft and Dataflow to groom the style of the hair within the tube. Alternatively, arbitrary volumes of any topology are procedurally combined to form a boundary for the domain of an incompressible fluid simulation (3b). Hair follicles become the source points for the fluid simulation, and artist directed areas on the boundary become the drains. We solve the static pressures in this domain to define directional flow streamlines for the procedural generation of hair (3c).

## 3 Adding Dynamics

HairCraft works with ILM deformable dynamics [Bowline and Kačić-Alesić 2011], which allows the simulation artist to preserve lookdev and manage sim complexity. Dynamics are added by procedurally indentifying strategic populations of hair and passing them through the standard Zeno deformation pipeline. The simulation artist alters resolution and quantity of simmable hair on a shot-by-shot basis to obtain higher fidelity simulations for close-ups. In addition, the entire deformation pipeline is available, including shaping tools for correctives. Post-sim graph processing may be inserted for removing penetrations or culling problematic hairs.

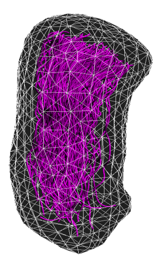

**Figure 5:** *Hair volume*

Some approaches for adding dynamics involve embedding hair in higher dimensional geometries (4). HairCraft allows these geometries to be procedurally computed on the fly from the source (5). Lookdev is free to proceed at the same time as dynamics setups are being created. The procedural nature of HairCraft even allows multiple approaches to be used together and blended across takes and shots.

## 4 Putting It All Together

HairCraft was forged during the production of *Warcraft* in which 287 photoreal assets had to be created and dressed with hair or feather geometry. Of these, there were 42 unique creatures with hairstyles and fur covered costumes. 22 of these assets required variants that spanned 128 levels of detail.


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